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Socioeconomic determinants of male mortality in Europe: the absolute and relative income hypotheses revisited

1. INTRODUCTION

During the last 30 years, both the levels of life expectancy and the levels of socioeconomic development have improved in Western Europe, albeit in a non-uniform way across countries. Previous studies, however, have shown that there is, at best, only a weak direct link between living standards and total mortality among wealthy nations at the international level. Already in 1975 Preston wrote that "*it is widely believed that mortality has become increasingly dissociated from economic level because of a diffusion of medical and health technologies, facilities and personnel that occurred, in large part, independently of economic level*" (Preston, 2007, p. 484). Other explanations for mortality differences between wealthy nations have also been provided. For instance, Mackenbach and Looman (1994, p. 140) suggested that "*the mortality increasing effects of urbanisation and industrialisation obscured the mortality lowering effects of high living standards*" as well as that country-specific factors such as dietary habits acted as confounders, while Wilkinson (1992; 1996) argued that it is not the richest societies among the developed countries that have the best health, but those that have the smallest income differences between rich and poor as he found strong evidence of a negative association between income inequality and life expectancy for nine industrialised countries. Almost a decade later Lynch *et al.* (2001) cast doubt on the results by Wilkinson (1992), as the association disappeared after including more countries in the same analysis. In an editorial by Mackenbach (2002) it was suggested that a better understanding of the potential importance of contextual factors for population health may come from data on mortality that permit a simultaneous analysis of effects of income on mortality at the individual and aggregate level. However, based on the results of three such studies published in the same issue of the British Medical Journal (Osler *et al.*, 2002; Shibuya *et al.*, 2002; and Sturm and Gresenz, 2002) he had to conclude that the correlation between income inequality and population

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health is slowly dissipating. According to Subramanian *et al.* (2003), though, a consistent factor in these and other studies with similar results was their small level of aggregation (parishes, wards, municipalities, counties). Analyses at US state-level, on the other hand, showed a more consistent effect of income inequality on health (e.g. Kaplan *et al.*, 1996; Kennedy *et al.*, 1996). A similar conclusion was provided by Wilkinson and Pickett (2006). Based on their review of 155 peer reviewed research papers, they concluded that "*income distribution is related to health where it serves as measure of the scale of the social class differences in a society*" (idid., p. 1778) and suggested that the few findings that were unsupportive of the relation between income distribution and measures of population health occurred when inequality was measured in areas too small to reflect the scale of social class differences in a society. Other reasons they gave for the lack of evidence in some of these studies was that they controlled for factors which, rather than being genuine confounders, are likely either to mediate between class and health or to be other reflections of the scale of social stratification. Furthermore, the international relationship was temporarily lost (in all but the youngest age groups) during the decade from the mid-1980s when income differences were widening particularly rapidly in a number of countries.

From this overview of the debate it may be concluded that the absolute versus relative income hypothesis is still undecided. What this paper adds to this discussion is that it introduces a number of methodological innovations into the empirical analysis. First, a distinction is made between western and eastern European countries. Next, we study not only all-cause mortality, but make a distinction between relevant causes of death. Third, we allow for a time lag in the effect of mortality factors. Finally, we use a pooled cross-section and time series framework to study the mortality trends at the national level of European countries.

A number of authors have advocated the use of multilevel methods in studying the relationship between income and mortality (e.g. Wagstaff and van Doorslaer, 2000; Lochner *et al.*, 2001; Subramanian *et al.* 2003; Dahl *et al.*, 2006). This research design would require the availability of mortality data at the individual level. Although such a framework would greatly enhance the understanding of relevant factors on mortality, such data are not yet available at the international level (Lochner *et al.*, 2001), and therefore beyond the scope of the current paper. The analysis reported here is at the macro level, and, since it is an ecological study, no causal relationship may be inferred at the individual level from the association that is established between the variable and the mortality outcome (Valkonen, 1993; Gravelle, 1998). Nevertheless, the associations are expected to be in line with what has been documented at the individual level.

2. ABSOLUTE VERSUS RELATIVE INCOME

2.1 Absolute income

Perhaps the most common indicator of the living standards of a country is per capita Gross Domestic Product (GDPc), a measurement of the average income of a person in a population. The fact is well established that there is a positive relationship between GDPc and health, as high-income countries are likely to consume more commodities that have a direct impact on the quality of life, such as housing, dietary and health care factors. Consequently, a changing state of the economy will also affect the health of a population. However, evidence is quite clear on the fact that the international relation between Gross National Income per capita and life expectancy not only grows progressively weaker as countries get richer, but disappears altogether among the richest (Wilkinson, 1997; Marmot and Wilkinson, 2001; Wilkinson and Pickett, 2006). One important reason for this diminishing returns with growing income is the effect of confounding factors which negate the positive association between income and health. For instance, lifestyle factors, industrialisation and urbanisation were found to partly confound the income-mortality association in Western Europe (Mackenbach and Looman, 1994).

2.2 Relative income

Although at the country-specific level, both life expectancy and economic development in Western Europe have increased virtually incessantly throughout the last 40 years, the life expectancy in wealthy countries such as the Netherlands and Germany have been surpassed by less wealthy countries such as Greece and Spain. To explain the differences between countries within Western Europe, one therefore has to look elsewhere. Wilkinson (1996, p. 3) proposed that "*what matters within societies is not so much the direct health effects of absolute material living standards so much as the effects of social relativities*". If that is the case, then variations in the *distribution* of income will become an important determinant of health differences between countries. Wilkinson and Pickett (2006) suggest that the studies on income inequality and mortality are most supportive in large areas because in that context income inequality serves as a measure of the scale of social stratification, or how hierarchical a society is. A more unequal society becomes more dominated by status competition and class differentiation and suffers a more widespread health disadvantage as a result. Therefore, larger class differences lead to a steeper social gradient in health. Recent evidence from Italy and top industrialised countries also shows that income inequality had an independent and more powerful effect on life expectancy at birth than did per capita income and educational attainment (De Vogli *et al.* 2005).

According to Lynch *et al.* (2000) the underlying causality between relative income and mortality is a neo-materialistic one. A society with greater income inequality will have a higher percentage of people with low incomes, and this higher prevalence of poor people accounts for the relation with poor health, not the relative income differences. Others, such as Marmot and Wilkinson (2001) argue that psychosocial factors mediate the relation between income inequality and mortality at the population level. Income inequality affects health through perceptions of place in the social hierarchy based on relative position according to income. Such perceptions produce negative emotions such as shame and distrust that are translated “inside” the body into poorer health via psycho-neuro-endocrine mechanisms and stress induced behaviours such as smoking.

2.3 East-West differences

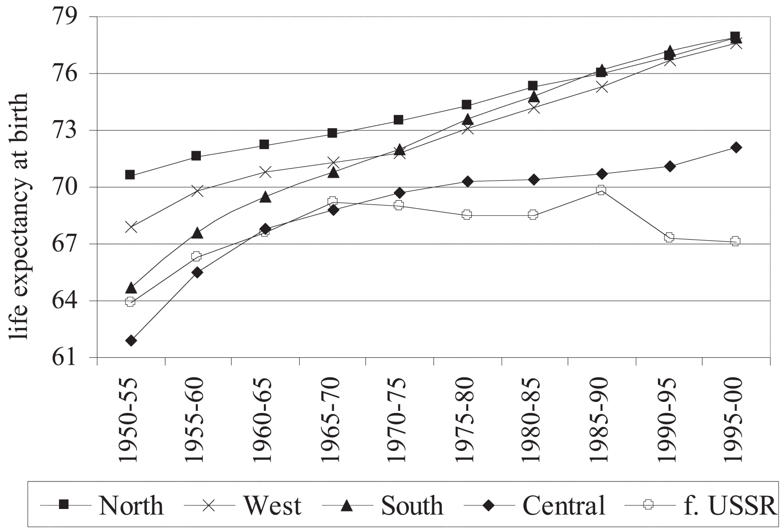
European countries are not homogeneous with respect to the effects of absolute and relative income on mortality. First, there are large differences in absolute income between European countries, particularly between western and southern countries on the one hand, and Eastern European countries on the other[2]. In the past, large differences also existed between southern and western European countries. While the West progressed in terms of economic development, much of Eastern Europe lagged behind even though, in the early 1960s, levels of GDPc did not differ that much between the two parts of Europe. After communism collapsed, an economic transition occurred very rapidly that led to large decreases in economic productivity, which prompted the emergence of unemployment, something that the population had not experienced before. This caused enormous stress for the residents of the Eastern Bloc, not only because jobs were no longer guaranteed, but also because many aspects of the social welfare system collapsed as well (Leon and Shkolnikov, 1998). The repercussions on population health were devastating: For instance, in Russia between 1990 and 1994, life expectancy for men decreased by six years to 57.7 years and for women by three years to 71.2 years – an unprecedented rate of deterioration in a country not at war *(ibid)*.

Compared with the current East-West mortality differences, differ-

[2] Throughout this paper a distinction is made between ‘western’ and ‘Western’ Europe, in which the former excludes countries of northern and southern Europe. When reference is made to ‘Eastern’ Europe it pertains to the countries of both ‘central’ Europe and ‘the former Soviet Union’ (see also note in Figure 1).

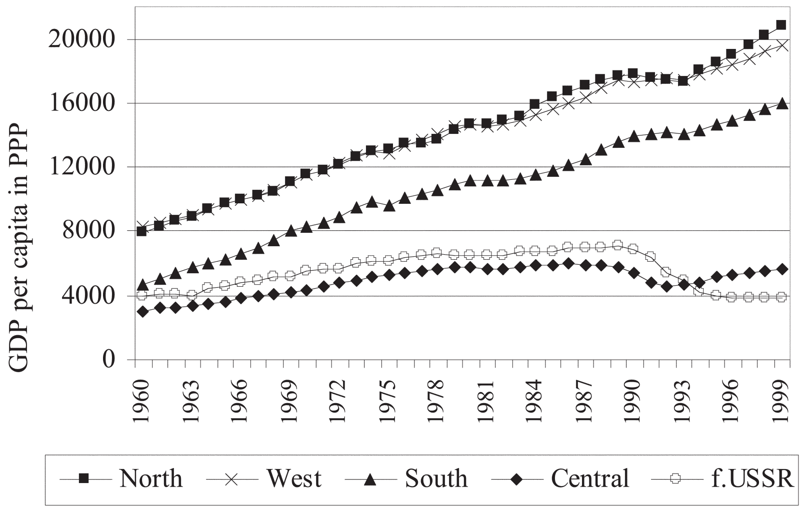
ences within Western Europe are much smaller. During the course of the last 40 years, mortality rates have been converging as southern countries (with the exception of Portugal) have caught up or even surpassed most other countries of Western Europe (Figure 1). However, in terms of economic development, absolute differences have been remarkably consistent throughout the same period, even though the four largest southern European countries have all joined the European Union well before the turn of the last century (Italy in 1950, Greece in 1981, Spain and Portugal in 1986). Coincidentally, western and northern Europe had virtually identical levels of GDPc in Purchasing Power Parities (PPP) throughout this period (see Figure 2). Given these income differentials across European countries, the absolute income hypothesis should not be discarded to explain mortality differentials, at least not for the period up to the late 1990s.

Figure 1 – *Life expectancy at birth in European macro-regions, 1950-2000*



Sources: United Nations (2001). Macro-region life expectancies are population-weighted averages calculated by the autors.
Note: North: Denmark, Finland, Norway, Sweden; West: Austria, Belgium, Switzerland, Germany, France, Ireland, Luxemburg, Netherlands, United Kingdom; South: Spain, Greece, Italy, Portugal; Central: Albania, Bulgaria, Croatia, Hungary, The Former Yugoslav Republic of Macedonia, Poland, Rumania, Slovenia, Slovak Republic, Yugoslavia, Bosnia and Herzegovina; former USSR: All of the 15 former Republics.

Figure 2 – *GDP per capita for the European macro-regions, 1960-1999*



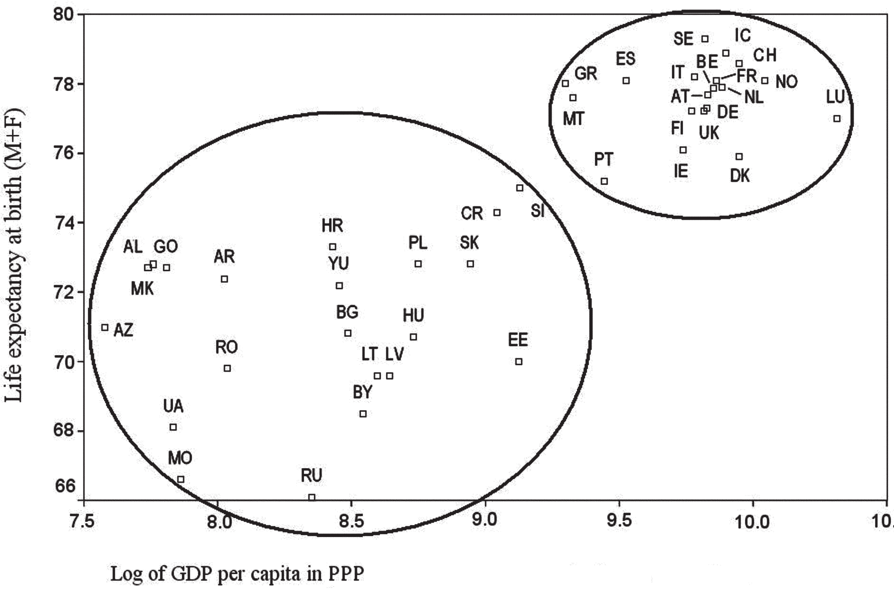
Source: Groningen Growth and Development Centre (2005); Maddison (2001).
Note: See Figure 1 for the countries that belong to each macro-region.

With respect to relative income, Eastern and Western European countries have had quite different histories. Until the collapse of the communist system by the end of the 1980s/early 1990s, income inequalities in the east were quite small compared to western countries (although they did exist), but inequality has increased dramatically since then. For instance, until the beginning of the transition period, unemployment did not officially exist in most of Eastern Europe and education was not an important factor in obtaining a well-paid job. This was because the state subsidised those branches that had high levels of unskilled labour and allocated resources to produce the greatest possible returns to the economy and society, particularly in terms of producer goods. Moreover, the industries were oriented towards a restricted market (in particular the former USSR) and insulated from technological and economic competition (Večerník and Matějů, 1999; OECD, 1996). Due to such differences with Western Europe, performing an explanatory analysis with variables that are conceptually different in some of the countries makes little analytical sense.

Both absolute and relative income may not be able to explain all the differences between East and West. Institutional differences are an important source of explanation as well. From the 1960s to the 1980s, Spain and Portugal (the two least developed countries in Western Europe) made great strides in life expectancy, while countries in Eastern Europe showed little progress (Guo, 1993). One reason for this development was that in the former Eastern bloc the communist party controlled all political and economic activity including the health care system. In order to compete with the West, these countries concentrated most of their effort on heavy industry and often ignored the non-economic sectors. Furthermore, the state-controlled media did not cover the popular health movement in the West, and this prevented the middle aged in Eastern Europe from adopting beneficial behavioural changes. The effectiveness of the prevention and treatment of cardiovascular diseases had been largely responsible for the increased life expectancy in the West, and the difference in mortality between adults in Western Europe and those in Eastern Europe was attributed to differences in this area *(ibid)*, although others suggest an interplay between health behaviour and medical care factors (e.g. Forster, 1996).

Recent empirical evidence also supports this division: in the late 1990s all Western European countries both observed higher life expectancies and higher levels of GDPc in PPP than the best performing Eastern European country (Figure 3). Notice also the lack of non-linearity *within* each of the two groups of countries.

Figure 3 – *Association between the log of GDP per capita and life expectancy at birth for all European countries with a population greater than 250,000, 1995-2000 (pooled)*



Sources: Life expectancy: United Nations (2001); GDPc: Groningen Growth and Development Centre (2005); Maddison (2001). The data for GDPc refer to the period 1995-99.

2.4 Cause of death

Total mortality trends are the outcome of different and sometimes even opposing cause-specific trends. Over time, cause-specific disease trends are the product of changes in the prevalence of exposure to its determinants (e.g. changes in tobacco consumption, dietary habits), a better control or elimination of disease determinants (e.g. as a result of improved hygiene, the discovery and application of vaccines) or the appearance of new ones (e.g. AIDS), or improved medical technology that eliminates, cures or has a palliative effect on the disease itself.

It is therefore considered that analysing cause-of-death groups is preferred to all-cause mortality because disease trends can be linked to trends in their risk factors that are sensitive to age- and cohort patterns (Tabeau *et al.*, 2001). This becomes especially relevant when a particular cause of death dominates the total mortality pattern due to its high prevalence. For example,heart disease in an all-cause model will largely reflect the dominant cause of death and other important developments may remain unobserved.

Moreover, disease determinants don't necessarily have the same effect on each cause of death. Alcohol consumption, for instance, may alleviate the risk of ischaemic heart disease (IHD) in the long term (Rimm *et al*., 1996), but augment the risk of stroke (Hart *et al*., 1999; Yuan *et al*., 1997) and sudden IHD if it concerns heavy drinking (Britton and McKee, 2000), and certain, but not all types of cancer (Clinton *et al*., 2000). Other determinants may affect certain diseases more than others, in which case, due to other disease determinants that are operating, overall mortality trends may be in opposite directions. For example, smoking is an important disease determinant of both lung cancer and heart disease. However, between the late 1970s and the mid-1990s there was a concurrent decline in heart disease and increase in lung cancer among southern European men (WHO, 2001, own calculations).

Finally, although the acute political and economic changes that took place in Eastern Europe provoked large temporary declines in life expectancy during the first half of the 1990s, it did not affect each cause of death to the same extent. For instance, cancer mortality rates were much less sensitive to the sudden societal changes than stress-related diseases such as heart disease, cronic liver disease and cirrhosis (from here on LDC). This is a logical outcome given the longer lag period between exposure and outcome with regards to cancer.

2.5 Using lagged values of explanatory variables

The influence of economic and other variables on mortality patterns is usually not contemporaneous, but the result of many years of exposure. A common example of this is smoking and lung cancer. Epidemiological research has indicated that, for individuals, a substantial decline in smoking levels instigates a fall in IHD mortality approximately 15 years later, while for lung cancer the lag is approximately 30 years (Ruwaard and Kramers, 1993). Sometimes, a mortality factor may have both a short-term and a long-term effect, and this lag may also be different between Eastern and Western European countries. For instance, alcohol has a long-term protective effect in Western Europe and a short-term detrimental effect in Eastern Europe. GDPc in PPP was given a zero lag in the Eastern European analysis and a value of 15 years in the Western European analysis under the assumption that a change in prosperity would have an immediate impact on mortality.

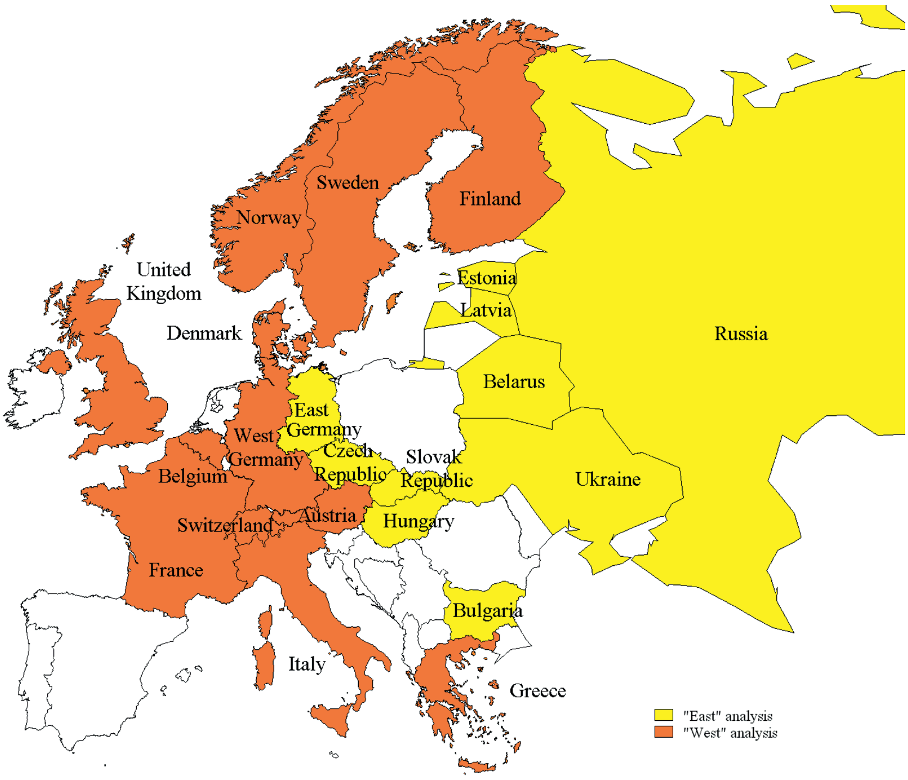
In summary, it is hypothesised that differences in mortality in Western Europe are primarily related to relative income, whereas differences in mortality in Eastern Europe are more due to absolute income. Both total mortality and a selection of the most important causes of death are analysed given that these two income measures are both associated with important disease determinants such as alcohol and tobacco consumption that affect some of the most prevalent causes of death. In this we consider that splitting up total mortality into several main causes of death better "isolates" the effect of the macro-economic indicators. We also take account of the fact that the effects of exogenous variables on various causes of death may have different time lags.

3. MATERIAL AND METHODS

Given the historical differences in economic development within Europe, separate models were applied to test the effect of income on mortality in Western and Eastern European countries (labelled 'West' and 'East') (Figure 4). In total, 12 current and former Western and 11 Eastern European countries were analysed for the periods 1977-99 and 1981-99, respectively. It was decided not to study beyond the turn of the millennium because even though the communist regimes collapsed by the end of the 1980s/early 1990s, throughout the 1990s the effects of the transition could be felt. However, since then a number of Eastern European countries have joined the EU which has blurred the once so apparent East-West differences in economic and demographic characteristics.

The main source for the national age-, sex- and cause-specific mortality data and age- and sex-specific population data was the *WHO Mortality* Database. Both the mortality and population data were already in, or could be aggregated to, the required 19, five-year age intervals (0, 1-4, 5-9, 10-14, …, 80-84, 85+). The mortality data contained causes of death that were coded according to the 8^{th}, 9^{th} and 10^{th} revision of the International Classification of Diseases (ICD). Despite the different revisions, there were no sudden breaks in the time trends of the causes of deaths that were analysed.

Figure 4 – *Map of countries used in the 'West' and 'East' analyses*



All-cause mortality and six cause-of-death categories were analysed: i.e. lung cancer, heart disease, cerebrovascular disease (stroke), respiratory system diseases, LDC and suicide. These were selected on the basis of their proportion to total mortality and known association with income inequality[3] (e.g. Turrell and Mathers (2001) for lung cancer; Kennedy *et al.* (1996), Turrell and Mathers (2001) and Kim *et al.* (2008) for heart disease and stroke; Kennedy *et al.* (1996) and Turrell and Mathers (2001) for pneumonia and bronchitis (important respiratory system diseases); McIsaac and Wilkinson (1997) for LDC; and Rodríguez Andrés (2005) for suicide). They respectively cover 63% and 69% of male total mortality in selected Western and Eastern European countries from the late 1970s/early 1980s to 1999 (see Appendix). With regard to heart disease,

[3] Not all previous studies show significant associations between income inequality and male mortality from the cause-of-death categories selected here. For instance, in the study by Lynch *et al.* (2001), the gini coefficient was insignificant or showed an opposite than expected association with regard to each of the six cause-of-death categories studied here as well as all-cause mortality. However, it was a cross-sectional study and they only adjusted for population size and GDPc.

a general category was formed by subtracting the stroke deaths from the entire circulatory system disease category, instead of analysing IHD and other forms of heart disease (OHD) separately, which is more commonly done. This is because these two cause-of-death categories and the combined remainder of the circulatory system diseases were not deemed internationally comparable. Similar aggregation of heart diseases has also been done in the past (e.g. Law and Wald, 1999; Murray and Lopez, 1996). Moreover, the most important macro-determinants of the specific heart diseases, as well as the symptoms and proximate causes (e.g. hypertension and smoking) are similar. Finally, at this stage, only male mortality was analysed because it is more sensitive to social, political and economic changes than female mortality.

The explanatory variables for which data could be obtained, together with their sources, are listed in Table 1. Data on pollution, unemployment, smoking, diet and government health expenditure could only be acquired for Western Europe. The cause-specific age-standardised death rates (SDR) that were calculated using the 1970 WHO standard population for Europe served as the dependent variable. Pooled cross-section and time-series analysis with country-specific fixed effects was employed to analyse the data, using the statistical programme EViews. Time-series data for each country were pooled in order to obtain a data set of N*T observations. By treating time and space as one dimension, the model explains the cross-country and inter-temporal variations in mortality simultaneously, producing a single effect for each independent variable. In order to capture some of the country-specific elements, fixed effects[4] were calculated (i.e. distinct intercepts estimated for each country). When results showed serial correlation in the error-term of the model, as indicated by the Durbin-Watson (DW) test, a first-order autoregressive term (AR(1)) was included[5]. Cross-sectional heteroskedasticity was removed by including cross-section weights. The modelling procedure started by including all independent variables and subsequently removing one by one the variables with the least significance until only those remained that had a one-sided p-value of 0.1 or less. Each excluded variable was retested for possible inclusion[6].

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[4] Results of these are not shown as the main purpose of the study was to look at the general effect of income on mortality rather than country-specifics. They may, however, be obtained from the authors upon request.

[5] A significant AR(1) term means that the probability of a positive/negative error term at time t, following a positive/negative error term at time t-1, is larger than that of an error term with a reverse sign. In the event of positive autoregression, an error-term at time t that is under - or over-estimated will be similarly under - or over-estimated at time t+1. Negative autoregression indicates the opposite: an under - or over-estimation of the error-term is followed by an over - or under-estimation.

[6] One reason for excluding insignificant variables from the models was to have a more meaningful balance between model fit and parsimony. Models with fewer variables tend to be more robust as they are less susceptible to multicollinearity, although some of the “independent effect” of the variable of interest may be lost.

Table 1 – *Overview of exogenous variables, their sources and descriptive statistics*

Variable	Measured as (source)
Per cap. Gross Domestic Prod.	Geary Khamis PPPs in 1990 US$ (1)
Income inequality	A value between 0 and 1 indicating the distribution of income (2)
Education	Number of years of education (3)
Secondary sector employment	% of the labour force employed in the secondary sector (4)
Primary sector employment	% of the labour force employed in the primary sector (4)
Divorce	Divorce Rate per 100 marriages (5)
Alcohol	Alcohol consumption – litres of pure ethanol per person (15+) per year (6)
Urbanisation	Percentage of the population resident in urban areas (7)
Unemployment	Total unemployed as % of labour force (8)
Pollution	Sulphur Oxides (1000 tonnes) per km^2 (9) (10)
Smoking	Tobacco consumption – grams per person (15+) per year (11)
Fruit (13)	Ave amount of fruits & vegetables available per person per year (kg) (12)
Health Care (GDP) (13)	Governmental expenditure on health as a % of GDP (11)

	Western Europe (1977-99) (14)				Eastern Europe (1981-99) (14)			
Abbrev.	Mean	Min.	Max.	St.dev.	Mean	Min.	Max.	St.dev.
GDPc	16256,4	8254,7	23943,6	3141,3	6925,9	2233,7	11034,3	1828,1
GINI	27,6	19,1	39,0	5,2	26,1	17,8	49,0	6,6
EDU	8,5	5,3	12,1	1,3	9,3	7,7	10,6	0,7
IND	30,2	20,8	45,5	5,4	38,5	23,9	47,0	5,2
AG	7,2	0,8	31,3	6,3	16,2	5,2	32,2	5,9
DIV	34,9	3,5	67,0	15,4	44,0	15,5	106,4	16,5
ALC	11,1	4,6	21,6	3,5	12,6	5,7	19,5	2,5
URB	74,4	56,2	97,2	12,2	67,7	54,7	77,3	5,8
UNEMP	6,5	0,2	17,9	3,5	3,5	0,0	17,3	5,0
POL	34,9	3,5	67,0	15,4				
TOBAC	2,9	0,1	13,4	3,2	Not tested			
FRUIT	2891,7	1256,0	5115,8	862,1				
HCGDP	204,6	109,3	441,8	79,2				

(1) Groningen Growth and Development Centre (2005); Maddison (2001).
(2) UNU-WIDER (2005); World Bank (2002). Other sources include: for Switzerland, Flückiger (2002, personal communications); for Norway, Statistics Norway (1999); for several Eastern European countries, Svenjar (2002); for Russia and the Ukraine, Gregory (1997).
(3) Barro and Lee (2000). For most countries, the data covered the period 1960-1990/2000 at five-year intervals. The intermediate years were fitted by means of a first-and-second order function.
(4) Data for Western Europe were obtained from Eurostat (2005); for Eastern Europe from ILO (2005); for former Czecholovakia from Federální Statistický Úřad (various years); for the Czech Republic from Český Statistický Úřad (various years).
(5) For most countries, data were obtained from Eurostat (2005); for the USSR successor states, Czechoslovakia and West Germany, some data were obtained from the Council of Europe (2001) and CIS STAT (1998).
(6) OECD (2005); Tekin (2002); Treml (1997).
(7) United Nations (2000).
(8) For Belarus, Bulgaria, the Czech Republic, Hungary, Latvia, Moldava, Poland, Romania, the Slovak Republic registered unemployment; source Western Europe: OECD (Main Economic Indicators) and Eurostat (Eurostatistics, ESVG-Aggregates) in: Gärtner (2000); source Eastern Europe: ILO (2005); source Ukraine CI STAT (1998).

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Table 1 – *Cont'd*

(9) Lefohn *et al.* (1999).
(10) Eurostat (2005).
(11) OECD (2005).
(12) WHO (2005).
(13) Data on per capita cereal availability and health care expenditure were also obtained but these variables were not used as they observed a correlation coefficients of ≥ 0.8 with, respectively, FRUIT and HCGDP.
(14) See 'Sample' below Table 2 for the countries in each analysis.

Before starting the pooled cross-section and time series analysis, lags were calculated for the exogenous variables. This was done for the same reason as when, for example, the effect of smoking or animal fat consumption and serum cholesterol on mortality is analysed (e.g. Alderson and Ashwood, 1985; Law and Wild, 1999), but which is rarely applied to absolute or relative income, i.e. that a certain time period elapses before an effect of a change in income on mortality can be established (an exception is the study on the effect of income inequality and cardiovascular disease by Kim *et al.* 2008 where each selected Gini coefficient preceded the respective outcome by a 5 - to 10-year lag to correspond to a plausible latency period for income inequality effects as was suggested earlier by Blakely *et al.* (2000)).

Because lags vary according to the a priori outcome, i.e. the cause of death, establishing the correct time lags is a difficult process and therefore they have been determined by a combination of theoretical reasoning (life course perspective and the aetiology of the disease), the available time series and empirical tests. The method employed was to conduct a pooled cross-section and time-series analysis for a range of lags for each variable separately, including AR(1) (if needed) and the cross-section weights, but excluding the other covariates. The various results were then compared and the lag corresponding to the highest value was taken as the 'true' one. Due to the rapid economic transformation and fluctuations in life expectancy in Eastern Europe, it was decided to conduct this lagging exercise separately for the two European analyses. GDPc, for instance, was given a zero lag in all but lung cancer in the Eastern European analysis under the assumption that a change in prosperity would have an immediate impact on mortality. Similarly, when analysing all-cause and heart disease mortality, results showed that overall, alcohol had a long-term protective effect in Western Europe and a short-term detrimental effect in Eastern Europe[7]. In the same way, as stroke deaths are also associated with heavy drinking (Yuan *et al.*, 1997) and often occur within several days of a weekend of binge drinking (the so-called Monday peak; Hart *et al.*, 1999), it was a-priori decided not to intro-

[7] No data could be obtained on drinking patterns, only on total consumption. This was unfortunate given that moderate consumption protects against the development of IHD (Rimm *et al.*, 1996) but elevates the risk of sudden IHD when consumed in large amounts over a short period in time (Britton and McKee, 2000).

duce a time lag for alcohol consumption in the model for stroke. Similarly, since previous research has shown that a decline in alcohol consumption leads to an almost immediate decline in LDC mortality (Ryan, 1995), lags greater than three years were not considered[8]. Lags relating to external causes of death are also generally no more than a few years. Conversely, as cancer develops gradually, lags are longer and assumed to be similar in the West and East analyses.

To sum up, the final model equation has the following form:

$$SDR^{c}_{i,t} = \alpha^{c}_{i} + \sum_{j} \beta^{c}_{j} X^{c}_{ij,t-r} + \mu^{c}_{i,t}$$

$SDR^{c}_{i,t}$ = the standardised death rate for cause of death c in country i at time t
α^{c_i} = fixed effect for country i and cause of death c
$X^{c}_{ij,t-r}$ = the value of the independent variable Xj for country i for cause of death c at time t, with lag r
β^{c}_{j} = the coefficient of the independent variable Xj for cause of death c the
$\mu^{c}_{i,t}$ = disturbance term[9]

4. RESULTS

For the purpose of this paper, we concentrate on the results of absolute income and income inequality. Where necessary we report the effects of controlling variables in the text. As shown in Table 2, the models fitted the data very well as the adjusted R^2 values ranged from 93.3% to 99.6% in the West analysis and between 91.9% and 99.6% in the East analysis The high R^2 can be explained by the inclusion of an autoregressive error term AR(1), cross-country weights (needed to eliminate cross-section heteroskedasticity) and fixed effects (needed to account for country-specific time invariant factors that are not represented by the variables). The Durbin-Watson tests showed that all models had an acceptable level of autocorrelation, i.e. values were either within or very close to the 5% significance level (cf. Savin and White, 1977).

[8] There were also country-differences in the way the amount of pure alcohol consumed was estimated (WHO, 2002) and few estimates of (illegal) home-made alcoholic beverages, tax-free purchases, smuggled spirits and alcohol consumed abroad. The underetimation of home-made alcoholic beverages particularly affects Eastern Europe (except Russia for which estimates exist and were used to approximate alcohol consumption levels in other former Soviet Republics; see Spijker, 2002). National consumption levels may be overestimated in the case of Estonia (since the break-up of the former Soviet Union Fins have been known to spend weekends consuming vast amounts of alcohol; Huang, 2000) and holiday destination countries in Southern Europe.
[9] When the autoregressive term AR(1) is included in the model $\mu t = \rho\mu_{t-1} + \varepsilon t$, where ρ is the first order serial correlation coefficient and εt the innovation in the disturbance. In effect, the AR(1) model incorporates the residual from the past observation into the regression model for the current observation (see Quantative Micro Software, 1994: pp. 301-3) as it corrects for serial correlation.

Table 2 - *Results from the pooled models for the various causes of male deaths*

	Total mortality	Lung cancer	Heart diseases	CRB	Respiratory sys.dis.	Chronic liver diseases + c.	Suicide
				West analysis			
Coefficient							
GDPc	-0,0190 ***	-0,0012 ***	-0,0042 *	-0,0031 ***	-0,0028 ***		-0,0009 ***
GINI					0,4674 *	0,1315 ***	0,1266 ***
Elasticity							
GDPc	-0,21	-0,18	-0,14	-0,49	-0,38		-0,56
GINI					0,16	0,18	0,14
Durbin-Watson	2,62	2,29	2,41	2,41	2,27	2,17	2,18
R^2 adjusted	98,64	99,58	98,72	98,09	93,27	99,28	97,88
AR(1)	0,78 ***	0,91 ***	0,93 ***	0,85 ***	0,46 ***	0,97 ***	0,84 ***
				East analysis			
Coefficient							
GDPc	-0,0623 ***	-0,0023 **	-0,0202 ***	-0,0043 ***	-0,0031 **	-0,0006 ***	-0,0023 ***
GINI	4,0296 *		2,2906 **		0,5717 **	0,1740 ***	
Elasticity							
GDPc	-0,27	-0,17	-0,23	-0,13	-0,20	-0,13	-0,35
GINI	0,07		0,10		0,14	0,15	
Durbin-Watson	1,84	2,17	1,78	2,03	1,94	1,70	2,05
R^2 adjusted	99,57	99,44	99,58	98,63	91,93	98,25	96,74
AR(1)	0,67 ***	0,86 ***	0,76 ***	0,79 ***	0,52 ***	0,81 ***	0,76 ***

(*Data sources and definitions*: mortality: WHO (2001; 2010) and main text; exogenous variables: see Table 1; * $p < 0.10$; ** $p<0.05$; *** $p<0.01$ (one-sided).
Method: GLS (GLS using Cross Section Weights; see Quantative Micro Software, 1994: p. 560).
Sample: 'West' analysis: Austria, Belgium, Switzerland, West Germany, Denmark, Finland, France, Greece, Italy, Norway, Sweden, United Kingdom; 'East' analysis: Bulgaria, Belarus, Czech Republic, Czechoslovakia, East Germany, Estonia, Hungary, Latvia, Russia, Slovak Republic, Ukraine.
Total panel (unbalanced) observations: *West analysis*: 255; *East analysis*: 170. Range in years 1977-99 in *West analysis* (except for West Germany; 1977-90), and 1981-99 in *East analysis* (except for East Germany; 1981-90, Czechoslovakia; 1981-85, Czech Republic; 1986-99 and Slovak Republic (1986-99).
Notes: Controlled for country-specific (so-called fixed) effects; and when significant: education, primary sector employment, secondary sector employment, divorce, alcohol consumption, pollution, urbanisation, unemployment, smoking, per capita availability of fruit, health care expenditure as a percentage of GDP and an AR-term. Elasticity is a form of standardised measure that estimates the relative change in the cause-specific mortality rate (m) as a consequence of a relative change in a determinant (x). In order to calculate this for a variable x, the average m-rate and x-value are required as well as the coefficient estimate of the x variable.

The estimated model coefficients show that absolute income differences (as measured by GDPc in PPP) was significant ($p<0.10$) for all-cause mortality and the individual causes of death, with the exception of chronic liver diseases in Western Europe. The associations are in the expected direction, thus indicating that at the population level higher absolute income leads to lower mortality. Clearly, absolute income differences matter, both in Western and Eastern Europe.

The effects of income inequality are mixed. Income inequality is not significant for total mortality, and three of the six causes of death in the West. It is significant and positive (as it should be) for respiratory diseases, chronic liver diseases and suicide. For respiratory diseases and suicide, the effect of income inequality is in addition to that of absolute income. For chronic liver disesases it is the only significant income indicator. In the East, the effect of income inequality is significant, in addition to absolute income, for all cause mortality, heart disease, respiratory system diseases and LDC. In all these cases, the effect of income inequality adds to the effect of absolute income, so the results show that it is not either/or, but additive. The eastern results for income inequality show that the effect is more pronounced here than in the West. The coefficient value for heart diseases is particularly large. This is somewhat surprising given that we know that income inequality was very low before the political and social changes that took place there.A large part of the disease-related mortality is the result of an accumulation of exposures across the life course, which are in turn powerfully affected by the social and economic experience of the individual (Davey Smith, 1997, Kuh *et al.*, 1997)[10].

The effects of the control variables are generally in line with expectations. In a number of cases, the effect of the two income variables is affected by the control variables[11]. With regard to the Western models, the addition of smoking consumption in the heart disease model allowed the coefficient for GDPc to become statistically significant. On the other hand, by including divorce in the respiratory system diseases model, the coefficient for income inequality became positive. In other words, part of the negative and positive association between absolute and relative distribution of wealth and mortality, respectively, in Western Europe is caused by the underlying changes and differences in behaviour. Also in the analyses of the Eastern European countries, the inclusion of one or more of the control variables in the models clearly influenced the association between GDPc and mortality. For instance, its association with CRB was doubled after including education in the model. Similar results were observed for respiratory system diseases after controlling for industrial employment, which simultaneously caused the association with income inequality to be positive and significant.

[10] Age-specific analyses of 'robustness' were performed (ages 45-64 and 65+) as certain exposures may be more profound at older or younger ages. This appeared to be particularly the case with the elderly in Eastern Europe as both absolute and relative income were insignificant on a number of occasions.

[11] To check for multicollinearity between a particular variable and the other variables in the model, each other variable was removed and subsequently returned from the model to ascertain the variable with the largest influence on the coefficient of the variable of interest. This variable was then deleted from the model and the procedure repeated until no removal would produce a large change in the coefficient of the variable of interest.

5. DISCUSSION

The main objective of this paper was to consider the influence of absolute and relative living standards (GDP per capita in Purchasing Power Parities and income inequality) on mortality differences between European countries. Rather than analysing all selected countries at once, Western and Eastern European countries were analysed separately. This was prompted in part due to their long period of diverging political and economic systems, which made it impossible to compare certain factors that were relevant for this study.

The analyses showed that both absolute and relative income differentials are important, but absolute prosperity was more important than relative prosperity. Moreover, absolute income played a greater role in Eastern Europe than in Western Europe. The fact that the effect of GDPc on total mortality (both in terms of the coefficient value and the elasticity, as shown in Table 2) was greater in Eastern Europe, where absolute standard of wealth is lower, was not unexpected. GDPc and mortality were not linearly associated with each other, i.e. health gains in the East will be greater for a given amount of extra wealth than in the West (although *within* both groups of countries little non-linearity could be discerned). More surprising was that absolute income was also an important variable for Western Europe, being significant in 6 out of the 7 models, including total mortality. This contradicts the proposition by Wilkinson (1992), who claimed that it is not the richest societies but developed countries who have the smallest income differences between rich and poor that have the best health. The results of Wilkinson and others in the past showing that relative income is the more important income indicator, is only valid for certain causes of death. If we compare the impact of both absolute and relative income on mortality we find that only for mortality in Eastern Eurpope related to LDC is the elasticity of relative income slightly higher than that of absolute income. In all other cases when both income measures were present in the model, the absolute income elasticity is higher, indicating that it has a stronger impact.

One reason why our results are likely to differ from previous studies is because of the consideration of several methodological issues. Perhaps most noteworthy was the introduction of lags in the exogenous variables. This was done for the same reason as when the effect of smoking or animal fat consumption and serum cholesterol on mortality is analysed (see, for instance, Alderson and Ashwood, 1985 and Law and Wild, 1999). It is rarely applied to absolute or relative income, i.e. that a certain time period elapses before an effect of a change in income on mortality can be established. In most instances a Gini coefficient preceded the respective outcome by a 5- to 10-year lag to correspond to a plausible latency period for income inequality effects as suggested by Blakely *et al.* (2000). The optimal lags were obtained by means of empirical testing, but within a theoretical range. For instance, while it is possible that sudden changes in the level of GDPc have an almost immediate impact on mortality levels from certain external causes, this is unlikely to happen with cancer mortality rates. The lagging of exogenous variables was, in a sense, a way of accommodating life course factors and indeed results would have been different in many instances when different lags were applied. A large lag suggests that it is the accumulation of exposure to risk factors and contextual experiences over a period that are important in determining mortality differences between countries and over time. This appeared to be the case more often in Western than in Eastern Europe. Conversely, there were more instances in the Eastern European models where a variable had the strongest association with a particular cause of death when no lag was introduced. In particular, it seemed that the recent economic and social transitions in the East had a more immediate impact on certain causes of death, as sudden changes in the level of both GDPc and alcohol consumption caused abrupt changes in mortality. It seems therefore that the optimum latency periods may differ according to the political and economic situation of the group of countries.

Methodological differences between this study and past studies play a role in explaining the differences in results. The pooled analysis of cross-sectional and longitudinal data was not applied before in this context, and the same applies for the introduction of lags in the explanatory variables. The results show that these elements have a significant impact on the outcomes of the models. In the attempt to estimate the effect of relative and absolute income on mortality from specific diseases, the explanatory variables that served as control variables had been selected on the basis of established associations with mortality. Particularly the dietary factors and smoking and alcohol consumption that are culturally embedded in society are therefore likely to remain important explanatory factors of international mortality differences and changes over time. The estimation of the independent effect of the income measures can still be improved by including other important dietary factors correlated with mortality such as past levels of animal fat consumption and serum cholesterol, i.e. risk factors of heart disease (Law and Wald, 1999). Similarly, the effects of additional indicators of psychosocial stress, other than divorce, should also be explored as they may mediate between income and health (Lynch *et al.*, 2001). For instance, control over work and life, social isolation, self-esteem and optimism over one's health have previously been linked to East-West mortality differences (Bobak and Marmot, 1996; Kristenson *et al.*, 1998), as well as to diseases that were associated with absolute and/or relative income in our study, namely heart disease (Hemingway and Marmot, 1999), LDC (Lynch *et al.*, 2001) and suicide (McLoone and Boddy, 1994).

Finally, one important East-West difference in the relationship between GDPc and mortality was the immediate effect of GDPc on non-cancer mortality in Eastern Europe, while a lag time of 15 years was needed to observe the strongest association in the Western European models for natural causes of death. The question is therefore whether an improvement in the Eastern European economy will lead to a similar type of association between GDPc and mortality as in Western Europe, i.e. that the main independent health benefits of GDPc will also become long-term rather than short-term. This conjecture was briefly tested by analysing each country separately and including GDPc twice in the model: once with a time lag of 15 years and once without a time lag. From the results it appeared that GDPc has a predominantly short-term effect up to the $10,000 level, after which the effect either disappears or is long term (not shown). Many Eastern European countries have recently joined the European Union and are receiving different forms of financial aid that aims to reduce the wealth gap with its Western members. It will therefore be worthwhile investigating if the immediate effect of GDPc on mortality still holds in Eastern Europe in the near future. However, the level of income inequality is also rising in the eastern European countries.This will likely have an effect on mortality as well. Similarly, it would be interesting to use the model coefficients to forecast mortality after 1999, first to compare the results with observed levels as a way to validate the models (and with an eye on a likely mortality effect that the current financial crisis should express if our model results are correct), and secondly, to produce short-term mortality scenarios.

Although we have made a number of methodological advances in the ecological analyisis of mortality differences in Europe, it is clear that these macro studies have their limitations. A combined study of mortality at the micro and macro level, using multilevel modelling, will become possible in due time, when internationally comparable micro data will become available for research. These studies should take as their starting point that both absolute and relative income are important, but context-dependent, and that in general, absolute income is the strongest predictor of the two. Another finding of the current study is also very relevant: substantial time lags should be taken into account as well. This would add an important but difficult-to-collect longitudinal dimension to the research design of such studies.

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Appendix

Causes of death selected for analyses, their ICD codes and contribution to total male mortality in Western and Eastern Europe between the late1970s/early 1980s and the late 1990s

Cause of death	International Classification of Diseases			West[a]	East[a]
	ICD-8	ICD-9	ICD-10	SDR per 100.000	
All causes	000-E999	000-E999	A00-Y89	1049	1600
				% del total	
Lung cancer	161-162	161-162	C32-C34	7.2%	6.0%
Stroke	430-438	430-438	I60-I69	9.6%	13.9%
Heart diseases	Rest of 390-458	Rest of 390-459	Rest of I00-I99	33.9%	38.2%
Respiratory system	460-519	460-519	J00-J99	8.2%	6.5%
Cirrhosis	571	571	K70-K76	1.9%	1.9%

[a]See 'Sample' below Table 2 for the countries in each analysis; Data source: WHO (2001; 2010)